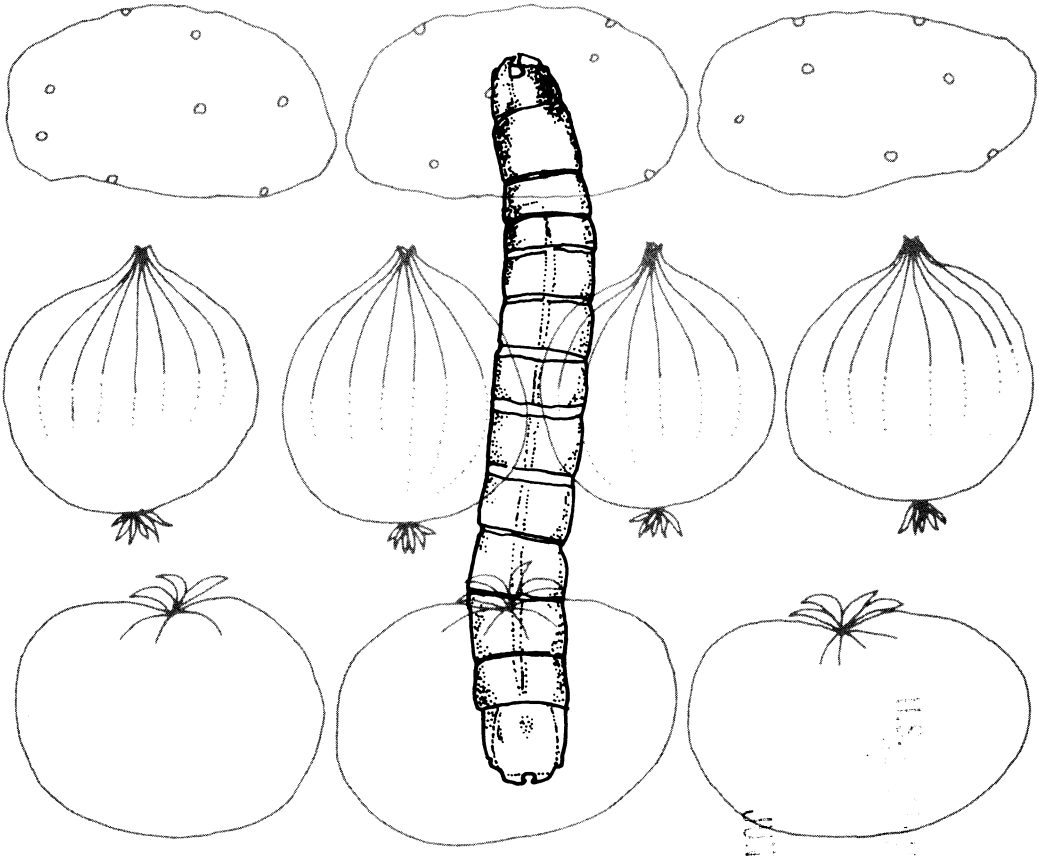
# WIREWORMS
## ON IRRIGATED LANDS IN THE WEST:
## How to Control Them



UNITED STATES
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## WIREWORMS DISCUSSED

Sugarbeet wireworm (*Limonius californicus*)
Pacific Coast wireworm (*L. canus*)
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Columbia Basin wireworm (*L. subauratus*)
Great Basin wireworm (*Ctenicera pruinina*)



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# WIREWORMS ON IRRIGATED LANDS IN THE WEST:

## How to Control Them

B. J. LANDIS[1] and JEROME A. ONSAGER, *ARS research entomologists*

Growers of commercial vegetable and field crops on irrigated lands in the West save millions of dollars annually by chemical and cultural control of wireworms.

Wireworms are the young (larvae) of click beetles. They live in soil and feed on underground parts of plants. They are recognized by their shiny, wirelike, yellow-orange bodies.

There are many kinds of wireworms in the West; five that cause most damage on irrigated lands are the sugarbeet wireworm, the Pacific Coast wireworm, the western field wireworm, the Columbia Basin wireworm, and the Great Basin wireworm.

Only the Great Basin wireworm can live in nonirrigated soil where the precipitation is low. It gradually disappears during the first 3 or 4 years of irrigation. The other four wireworms live in irrigated soil. They usually appear 5 or more years after irrigation begins and may persist indefinitely.

No crop is known to be free from attack by wireworms; crops particularly susceptible to attack are potatoes, onions, lettuce, melons, beans, tomatoes, peas, carrots, and sugarbeets.

## DAMAGE

Wireworms damage crops in two ways. They kill seeds and seedlings, and they injure tubers, roots, and bulbs. Damage is most severe during cool, moist weather. Hot, dry weather causes wireworms to move down in the soil away from the most susceptible parts of plants.

Early in the growing season, wireworms reduce crop stands by eating seeds or by cutting off seedlings slightly below ground level. If the damage is severe, replanting may be necessary (figs. 1 and 2). Later in the growing season, wireworms tunnel and scar maturing tubers, roots, and bulbs (figs. 3, 4, and 5).

Although replanting is expensive, wireworm damage to tubers, roots, and bulbs may result in a greater loss. A damaged crop must be destroyed or sold for feed at a low price.

[1]Deceased.

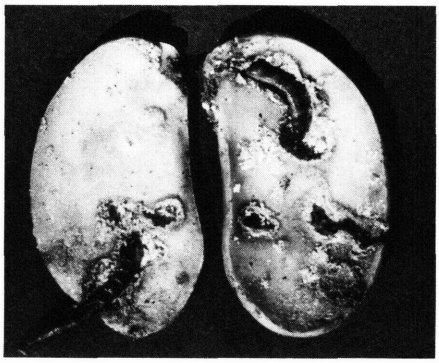

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Figure 1.—Wireworm damage on germinating lima beans.

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Figure 2.—Field of onions damaged by wireworms.

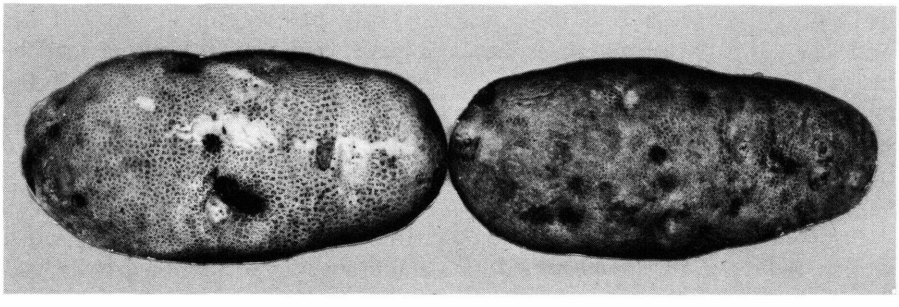

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Figure 3.—Potatoes scarred by wireworms.

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Figure 4.—Wireworms feeding on carrots.

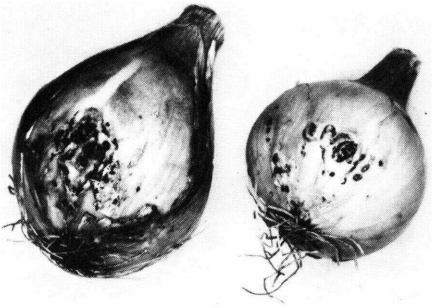

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Figure 5.—Onions with holes made by wireworms.

## DETECTING AND ESTIMATING WIREWORM POPULATIONS

Determine whether wireworms are present in your fields before planting. You can detect and count them by sifting samples of soil. If wireworms are found, you can either treat the soil or plant crops that are least damaged by wireworm attack. *The sooner wireworms are detected, the greater choice you will have in selecting a satisfactory control measure.*

Before getting your soil samples, be certain that the soil at the 6-inch depth is between 45° and 85° F. The first step in getting samples is to dig 20 well-scattered test holes per acre of land. Dig them with a 6-inch post-hole auger or irrigation shovel, and dig them 12 inches deep.

Soil samples can be examined for wireworms most easily by using a portable shaker and sifting tool (fig. 6). A 36- by 1-1/2- by 1/4-inch piece of spring steel serves as a flexible pedestal. A disk welded near the bottom of the pedestal serves as a base, and a metal bracket welded to

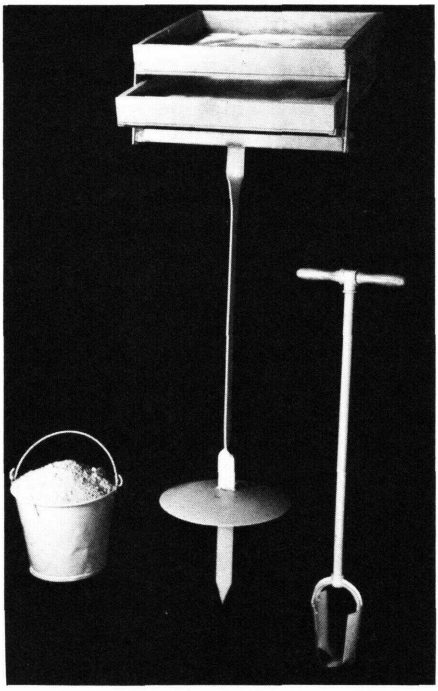

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Figure 6.—Portable shaker and soil-sifting tool (center) for detecting wireworms in fields before planting.

the top of the pedestal holds two sieves, or screens. The sieves are made by tacking wire screen to wood frames. The frames are made of 1- by 3-inch stock; they are 24 inches long and 24 inches wide.

Place 4-mesh (coarse) screen on one frame and 14-mesh (fine) screen on the other. The coarse screen will loosen the soil and separate plant debris and stones. Wireworms, if present, will fall onto the fine screen where they may be counted.

If no wireworms are found in the soil from 20 holes per acre, it should be safe to plant any crop. If five or more are found, damage to susceptible crops can be expected, and the soil should be treated with an insecticide.

## DESCRIPTION

### Eggs

Wireworm eggs are pearly white, nearly round, and about 1/50 inch long.

### Larvae

Newly hatched wireworms (or larvae) are white, have dark jaws, and are about 1/16 inch long. After feeding and molting several times, they become hard, shiny, and dark yellow. They have three pairs of legs, and the last segment of their bodies is pronged or forked behind (fig. 7). Wireworms ordinarily seen in the soil are 1/4 to 3/4 inch long; these larger and older wireworms cause most damage to crops.

### Pupae

The pupae (fig. 7) are white and very fragile. They resemble adult wireworms in size and shape, and become grayish or brownish just before reaching the adult stage.

### Adults

The adults (fig. 7) are slender, hard-shelled beetles. They are tan to dark brown or black, and 1/3 to 1/2 inch long. They are popularly known as click beetles or snapping beetles, from their habit of snapping the forepart of their bodies when they are held between the fingers or placed on their backs.

## LIFE HISTORY AND HABITS

The pupae transform into adult beetles in summer, but the adults do not emerge from the soil until the next spring, when temperature in the top 3 inches reaches 55° to 65° F. In southern California the beetles begin to emerge about March 1 and may continue to emerge until early May. In the Pacific Northwest they emerge from mid-April to early June.

The male beetles emerge and crawl about on the soil or rest on vegetation. On warm, sunny days they make short flights in search of females.

Female beetles emerge, mate, and immediately burrow back into the soil. They begin to lay eggs within a few days. After laying most of their eggs, they emerge again and make

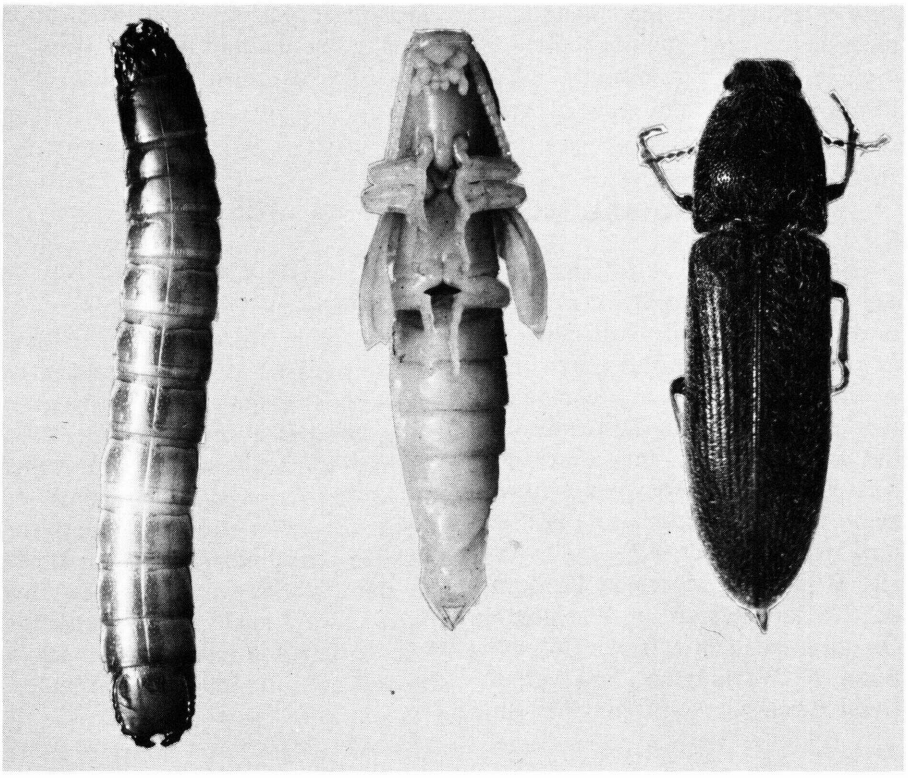

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Figure 7.—Stages of the sugarbeet wireworm: *Left to right,* full-grown larvae, pupa, adult beetle. All enlarged.

short flights, often to nearby fields, where they lay the rest of their eggs. This is the way infestations spread.

Each female lays 50 to 350, or more, eggs. The eggs are placed close together, 1 to 6 inches deep in moist soil. They hatch in 3 to 4 weeks under favorable conditions, but will dry out and die in a few hours when exposed to air.

Many newly hatched wireworms starve, drown, or dry out while burrowing through the soil in search of food. In Washington, Oregon, and Idaho, the larvae cause no measurable damage their first year but can cause much damage their second year. In southern California larvae may cause damage as early as July of their first year.

When food, moisture, and temperature are favorable, a few larvae become fully grown within 1 year, but most require 2 to 5 years. Under unfavorable conditions they may require 6 years or more.

The full-grown larva makes a small cell 3 to 8 inches below the surface of the soil in July or August. The larva sheds its last larval skin in the cell and transforms into a white pupa. During the next 3 weeks the pupa gradually changes to an adult wireworm.

In Washington, Oregon, and Idaho most wireworms complete their life cycle in 3 years; but in southern California, it may take only 2 years. Therefore, generations of wireworms usually overlap and larvae of various sizes may be present in a field.

## SEASONAL MOVEMENTS IN THE SOIL

Wireworms are quite sensitive to soil conditions. Except for the Great Basin wireworm, they will not enter or remain in dry soil. As the surface of the soil cools in late summer or fall, wireworms move downward in the soil for winter; they descend as deep as 24 inches. They move upward again when the temperature at the 6-inch depth reaches 40° F. This usually is in early March in California and in late March in Washington, Oregon, and Idaho. In the Columbia Basin of Washington, however, the Great Basin wireworm may be found near the surface of the soil late in February.

The number of wireworms present near the soil surface gradually increases through May. Starting in June, when the surface temperature of the soil reaches 80° F., wireworms move downward again and most of them stay below the 6-inch depth for most of the summer unless the fields are densely shaded. Some wireworms move upward again in September for a short time, but most remain deep in the soil until the following spring.

## CHEMICAL METHODS OF CONTROL

Five insecticides are recommended for control of wireworms in the West. They are ethylene dibromide, Telone, fonofos, parathion, and diazinon. These insecticides have certain limitations and must be applied at the right time and in the right way to be most effective. Consider the limitations of each insecticide and decide which insecticide is best suited to your particular cultural program.

Ethylene dibromide and Telone are soil fumigants that kill wireworms very quickly. They are short lived, however, and become ineffective after about 3 weeks in the soil.

Fonofos, parathion, and diazinon also kill wireworms very quickly. They persist in the soil a little longer than the fumigants.

### Soil Fumigation

When introduced into the soil, ethylene dibromide and Telone evaporate slowly and form poisonous gases that spread through the soil and kill wireworms.

Do not use ethylene dibromide or Telone when the soil temperature at the 6-inch depth is below 50° F.

*Ethylene dibromide.*—Ethylene dibromide is usually sold as a heavy, 83-percent solution containing 12 pounds of ethylene dibromide per gallon. If your equipment will deliver 3 gallons (36 pounds of active ingredient) per acre, ethylene dibromide may be applied without dilution. If your equipment delivers more than 3 gallons per acre, add 7 gallons of any

petroleum thinner for each 3 gallons of 83-percent ethylene dibromide. Mix the solution thoroughly by circulating it through your equipment, and apply it at 10 gallons per acre.

Ethylene dibromide at 36 pounds of active ingredient per acre is recommended for control of wireworms in soil to be planted to asparagus, cauliflower, cucumbers, eggplant, lettuce, melons, okra, peppers, potatoes, strawberries, or tomatoes.

*Telone.*—If soil is infested only with wireworms, you may apply undiluted Telone at 20 gallons per acre.

If nematodes or garden symphylans are also present, they, too, can be controlled with Telone. However, the rate of application may have to be increased to as much as 40 gallons per acre. Consult your county agricultural agent for specific rates of application before you apply Telone for nematodes or garden symphylans.

Telone is recommended for control of wireworms in soil to be planted to potatoes or sugarbeets.

## Preparation of Soil for Fumigation

Plow the soil deep, and loosen it as much as possible before applying fumigants. If a hard plowsole or shallow caliche layer is present, use a subsoiler before plowing. Then work the surface layer of soil into seedbed condition.

The soil must be relatively free of nonrotted plant debris—for example, potato vines or cornstalks—when fumigants are applied to the soil. Nonrotted plant debris often results in poor control because it clogs the applicator and absorbs the gases.

## Fumigation Methods and Equipment

Apply fumigants when the soil at the 6-inch depth is 50° F or above, and neither too dry nor too wet to till properly. Treat sandy soil when it is moist; treat silt- or clay-loam soils when they are relatively dry.

Fumigants should be placed at least 8 inches deep in the soil. They may be applied with a chisel applicator (fig. 8) or plowsole applicator (fig. 9).

Pack the soil lightly immediately after treatment to seal in the fumigant. Use a roller, float, cultipacker, or similar piece of equipment for sealing in the fumigant, and do not disturb the soil for 3 weeks.

You can apply fumigants with several kinds of applicators, but the soil can be treated fastest and most uniformly with a chisel applicator (fig. 8). If you apply a mixture of ethylene dibromide and a petroleum solvent, a bypass pipe and valve arrangement below the pump may be used to return the chemicals to the tank to insure mixing before application.

The fumigant usually is pumped under pressure through a manifold so the same amount of material can be delivered to the soil through each

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Figure 8.—Chisel applicator showing fumigant tank, pump, and chisels with tubes leading to the soil.

chisel. The fumigant is carried to the desired depth in the soil through a metal tube that is welded to the back of each chisel and is released through a spray nozzle. An applicator with 5 to 14 chisels can treat 10 to 40 acres of soil a day.

Chisels should be spaced 12 inches apart and staggered on a double tool bar. In calibrating a rig with 12-inch spacings, the number of feet you should travel while releasing 1 pint of liquid per chisel can be calculated as follows:

$$\frac{43{,}560}{\text{gallons per acre} \times 8} = \text{number of feet}$$

For example, if you want to apply 3 gallons of undiluted ethylene dibromide per acre, apply 1 pint per chisel for each 1,815 feet traveled. Computation is as follows:

$$\frac{43{,}560}{3 \times 8} = \frac{43{,}560}{24} = 1{,}815 \text{ feet}$$

Fumigants corrode some metals, particularly iron. It is best to use stainless steel tanks, brass fittings, and corrosion-resistant tubing on your application equipment. Drain applicators and clean them thoroughly with stove or diesel oil after each use.

Plowsole applicators (fig. 9) may be used for small fields. They can be made from a secondhand gasoline tank, some 1/4-inch copper tubing, and two or more valves. The fumigant is led by gravity from the storage tank through the tubing to the plowsole just ahead of each bottom. Needle valves regulate the flow of each outlet tube and a shutoff valve (fig. 10) is used between the tank and the tubing.

Since no pressure is applied to the fumigant in this method, 10 gallons per acre is about the smallest amount that can be delivered uniformly with accuracy. The rate of flow must be adjusted to the width of the furrow and the speed of the tractor. The rates of flow necessary to deliver 10 gallons per acre for three furrow widths at several tractor speeds are as follows:

| Tractor speed (feet per minute) [1] | Fluid ounces per minute needed to deliver 10 gallons per acre | | |
|---|---|---|---|
| | 12-inch furrow | 14-inch furrow | 16-inch furrow |
| 250 | 7½ | 8½ | 10 |
| 300 | 9 | 10 | 12 |
| 350 | 10 | 12 | 14 |
| 400 | 12 | 13½ | 15½ |
| 450 | 13 | 15½ | 17½ |
| 500 | 14½ | 17 | 19½ |

[1] Eighty-eight feet per minute equals 1 mile per hour.

## Soil Aeration After Fumigation

An odor may still remain in the soil 3 weeks after a fumigant has been applied. If it does, the soil must be aerated before crops may be planted safely. The label on the fumigant container lists crops that require soil aeration.

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Figure 9.—Two-way plowsole applicator showing fumigant tank with tubes leading to soil.

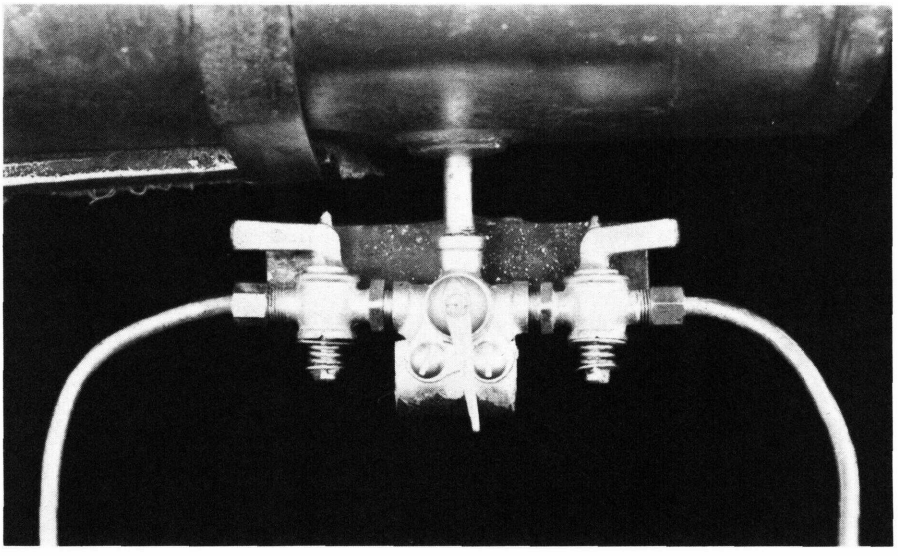

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Figure 10.—Shutoff valve (center) and two needle valves used between fumigant tank and tubes of two-way plowsole applicator.

To aerate the soil, break it up with a spring-tooth harrow or similar tillage implement. Do not plant until the fumigant odor has gone.

## Soil Insecticides

Fonofos, parathion, and diazinon are available in liquid, powder, and granular forms.

They are short-lived insecticides and remain effective against wireworms for the longest time when applied in granular form.

### Timing of Applications

*Fonofos, parathion, or diazinon should be applied in the spring, but not until the temperature of the soil at the 6-inch depth is at least 50° F.*

Unlike the soil fumigants, which form gases that spread through the soil, fonofos, parathion, and diazinon fume very little. Therefore wireworms must come in contact with these insecticides to be killed. Although short lived, these insecticides will give good control if applied when most of the wireworms are in the top 9 inches of the soil.

Although fonofos, parathion, and diazinon will control wireworms rather quickly, they are not persistent, and applications may have to be repeated every 2 or 3 years to prevent reinfestation of the soil.

Diazinon is much less toxic than fonofos or parathion to man. But neither insecticide is toxic to seeds, roots, bulbs, or tubers when applied as recommended. Unlike the fumigants, they may be applied to soil immediately before planting.

Forty to 60 pounds of 10-percent parathion granules per acre are recommended for control of wireworms

in soil before planting beans, broccoli, brussels sprouts, cabbage, carrots, cauliflower, celery, eggplant, kale, lettuce, melons, onions, peas, peppers, rutabagas, potatoes, tomatoes, or turnips.

Twenty-eight pounds of 14-percent diazinon granules per acre are recommended for control of wireworms in soil before planting beans, broccoli, cabbage, carrots, cauliflower, celery, collards, cucumbers, endive, kale, lettuce, melons, onions, parsley, parsnips, peas, peppers, potatoes, spinach, squash, sugarbeets, sweet corn, swiss chard, or tomatoes.

Twenty to 40 pounds of 10-percent fonofos granules per acre are recommended for control of wireworms in soil before planting field corn, pop corn, potatoes, and sugarbeets.

## Application Methods and Equipment

*Insecticides should be applied evenly over the soil and then mixed thoroughly to a depth of 6 to 9 inches.* Work the soil vigorously with a heavy tandem disk immediately after application. Two diskings may be better than one. *The deeper and more thorough the mix, the better the control will be.*

Heavy soils should be plowed before they are treated. Light, sandy soils need not be plowed if they are disked deeply and vigorously after treatment.

Granulated insecticides can be applied with some kinds of dry fertilizer spreaders or with special granular applicators. Insecticide applicators are available in several widths, and some can be mounted on a wheel-frame disk. You can apply and disk in the granules in one operation with a mounted applicator. From 30 to 40 acres can be treated in 6 to 7 hours at driving speeds of 4 to 5 miles per hour.

Granules can be applied in small fields with a crank-type grass seeder. The person operating the seeder may walk or ride in the back of a pickup truck. Fonofos or parathion granules *should not* be used in a hand applicator.

Fonofos or diazinon may be applied for wireworm control on potatoes as a side dress at planting time using only half as much material as recommended for broadcast treatments. However, in experiments, side-dress applications of diazinon were only 75 to 85 percent as effective as broadcast applications. Side-dress applications of fonofos were usually about as effective as broadcast applications.

*Do not apply insecticide granules mixed with granulated fertilizer.* The insecticide granules are smaller than most fertilizer granules, and they may settle out in bags, truck beds, or applicator hoppers. This results in uneven distribution of insecticide and poor wireworm control.

# CULTURAL METHODS OF CONTROL

Cultural methods of wireworm control are based on the behavior of wireworms under various soil conditions and farm practices. In Washington, Oregon, and Idaho, where studies were carried on for over 10 years, it was found that farmers often can prevent serious wireworm

damage by systematic crop rotation and certain cultural methods.

## Water Use

The Great Basin wireworm disappears from soils after 3 or 4 years of irrigation. If nonsusceptible crops are grown for the first 3 years, you will not need to apply insecticides for this wireworm.

The other wireworms require moisture and live in irrigated soils or near streams. If the top 15 inches of soil in a field is allowed to remain very dry for several weeks in summer, most larvae—particularly the young ones—will die.

If soil drying can be fitted into crop rotation so that heavily infested fields can be dried once every 5 or 6 years, wireworm populations can be kept below the number that will cause commercial damage. Drying of the soil to kill wireworms can best be accomplished by withholding irrigation water from good stands of alfalfa or fall grain just before it is harvested. Drying is most effective on first- and second-year wireworms in sandy- to silt-loam soils, but many larger wireworms are killed by this method.

## Cultivation

Wireworm populations can be reduced by plowing infested fields in summer. Mechanical injury to the pupae and exposure to summer heat and low humidities account for most of the mortality at this stage. If you plow fields that have been in small grain or early truck crops between July 15 and August 15, you will materially reduce the number of adult wireworms that will lay eggs the following spring.

## Rotation of Crops

Wireworms increase rapidly when red clover or sweetclover is grown on infested land for more than one season. The small grains, particularly barley and wheat, also promote rapid increase in wireworms.

In contrast with clover, alfalfa usually reduces wireworm populations. It is not a favorable food for wireworms and usually creates a dry, compact soil condition that is disagreeable to wireworms. The beneficial effects of alfalfa for wireworm control can be greatly increased by omitting irrigation until after the first cutting each year, thereby preventing survival of the new-brood wireworms.

The best rotation for keeping wireworms at a low level is 3 to 4 years of alfalfa followed by 1 year of potatoes and 1 or 2 years of other truck crops, such as sugarbeets, corn, beans, or peas. The growing of truck crops continuously in the same soil may increase the number of wireworms until chemical or other cultural control measures become necessary.

# USE OF PESTICIDES

This publication is intended for nationwide distribution. Pesticides are registered by the Environmental Protection Agency (EPA) for countrywide use unless otherwise indicated on the label.

The use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This Act is administered by EPA. According to the provisions of the Act "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12 (a) (2) (G))

EPA has interpreted this Section of the Act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State agricultural experiment stations, or county extension agents for information applicable to their localities.

The pesticides mentioned are available in several different formulations that contain varying amounts of active ingredient. Because of this difference in active ingredient the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated in the publication. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound of active ingredient equals 2 pounds of a 50% formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers on all pesticide containers. Use only pesticides that carry one of these registration numbers.

USDA publications that contain suggestions for the use of pesticides are normally revised at 2-year intervals. If your copy is more than 2 years old, contact your Cooperative Extension Service to determine the latest pesticide recommendations.

The pesticides mentioned in this publication were federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

## Special Precautions

Diazinon and ethylene dibromide can be absorbed through the skin in harmful quantities. When working with these insecticides, in any form, take the same precautions as with concentrates.

Do not transfer ethylene dibromide or Telone from one container to another in a closed room, and do not breathe their fumes. It you spill either of them on your skin, wash it off promptly with soap and water. Remove immediately clothing or

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shoes that have been wet with the liquid; otherwise, severe blistering may result.

Fonofos, parathion, and Telone are highly toxic and may cause death if swallowed, inhaled, or absorbed through the skin. They should be applied only by persons who are thoroughly familiar with their hazards and who will assume full responsibility for their safe use and comply with all precautions on the container label. After applying parathion to soil, keep all persons and animals off treated area for 48 hours.

Avoid drift of diazinon, fonofos, or parathion to bee yards or to crops in bloom.

PROTECT
*Use Pesticides Safely*
FOLLOW THE LABEL
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